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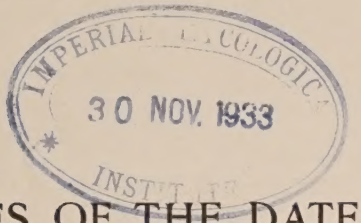

DISEASES OF THE DATE PALM, PHOENIX DACTYLIFERA

H. S. FAWCETT AND L. J. KLOTZ

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INTRODUCTION

It is the purpose of this bulletin to present the results thus far obtained in an investigation of date palm diseases in California and to include a description of other date palm diseases that have not yet been found in this state. The date palm industry is already well established in California and Arizona and is showing a steady growth. A census of palms reported by B. L. Boyden(1) in 1929 showed approximately 214,000 palms in California and Arizona distributed as follows: 136,000 in Coachella Valley, California; 30,000 in Imperial County, California; 30,000 in the Salt River Valley, Arizona; and 18,000 in the Yuma district, Arizona. It is estimated that about half of these are between 1 and 5 years of age. About 3,000,000 pounds of date palm fruit were produced in California and Arizona in 1930.

Information on the history, general culture, and varieties of date palms in California and the Southwest, which may have a bearing on date palm diseases, is given in the publications of Swingle,(24, 25, 26) Fairchild,(9) Kearney,(14) Toumey,(27) and Popenoe,(21) and the Annual Reports of the Date Growers' Institute held in the Coachella Valley since 1924.

In 1926 Fawcett(10) took up an investigation of date palm and other palm troubles in California at the suggestion of W. T. Swingle, in charge of the date investigations of the United States Department of Agriculture, and H. J. Webber, Director of the Citrus Experiment Station at that time, and at the urgent request of some of the leading date growers of Coachella Valley, who called attention to several diseases and abnormalities. The study of these diseases has been carried on as time would permit. Some observations and study of date palm diseases in the Coachella Valley had been made several

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years previous to this by C. O. Smith, J. T. Barrett, and others, but no one had been able to take the time to follow up any of the work continuously. In 1927 Fawcett[11] discovered the cause of *Diplodia* disease and gave suggestions for control.

In the autumn of 1929 Klotz began investigations of date diseases and presented reports at the Date Institutes in 1930[16] and 1931.[17] Klotz discovered the cause of the black scorch disease during 1930 (Klotz and Raby[19]).

In Arizona, Brown[2, 3] and Brown and Gibson[4] have carried on an investigation of the brown spot of date, and R. B. Streets read a paper (unpublished) on a rot of date palm trunks at the Date Institute in 1930.

In North Africa recent contributions to the study of date palm diseases have been made by Maire and Killian[20] in Algeria. Chabrolin[8] has also published recently a good general account of date diseases with a bibliography in which 33 previous publications are cited. Early in 1930 Fawcett[12] spent some time in Algeria, Tunisia, and Egypt, making observations and a study of date palm diseases.

Since many thousands of date palm offshoots have been brought into the Southwest from North Africa and Mesopotamia, they have probably brought with them most of the fungi commonly occurring in the oases from which these palms originated. Many of the fungi associated with disease are capable of remaining alive on certain dead parts still attached to these young palms and would not be noticed except by a plant pathologist or mycologist, and would not be seen even by them without special study of the subject. Since plant pathological investigation, especially of the date palm, had not advanced very far when the date palm began to be introduced into the Southwest, it was inevitable that diseases which could easily be carried on young palm parts would be introduced. No blame is to be attached to those importing the palms, however, since little was known of the diseases at the beginning of importation. If the diseases had been thoroughly studied before this time, the entrance of most of them might have been prevented.

The problem demonstrates the necessity of a thorough study of diseases of any given crop in the country in which it originates. Such a procedure would furnish a basis for intelligent handling of its importation into new locations. This now applies especially to the bayoud disease in Morocco, the most destructive date palm disease yet known. The escape of this country from the bayoud disease is probably due to the fact that no successful importations are known to have been made to California or Arizona from the oases where this disease

exists. The only palms in this country from the general region suffering from this disease are those of the Medjhool variety sent from a disease-free garden in Morocco by Swingle[26] to an isolated place in the desert in Nevada in 1927. These palms are quite free from disease after a period of about four years, but are still being carefully watched under strict quarantine.

DISEASES FOUND IN CALIFORNIA AND THE SOUTHWEST

The following diseases have been found in California or the Southwest. The *Diplodia* disease, decline, black scorch, brown spot, and blacknose may be considered as major troubles. The remainder may be considered of minor importance at present, but may prove to be more troublesome later as the trees become older.

DIPLODIA DISEASE

The *Diplodia* leafstalk and offshoot disease was first studied in the Coachella Valley on the Deglet Noor variety by Fawcett[10, 11] in 1927. A fungus which has been identified as *Diplodia phoenicum* (Sacc.) n. comb., was isolated from diseased leaves, and the characteristic symptoms were reproduced by inoculation experiments. The disease has since been found in many of the date palm gardens of California and Arizona. It was also observed near Tozeur in Tunisia, North Africa, by Fawcett[12] in 1930. It was learned that offshoots from this region had been brought into California by the United States Department of Agriculture.

Symptoms.—In severe cases the disease results in death of offshoots either while they are still attached to the mother palm or after they have been detached and planted. The disease also causes a premature death of leaves in older palms.

In offshoots the disease manifests itself in two distinct types: one in which the outside leaves die first and the younger shoots and bud union remain alive for some time; and another in which the dying-back of the center of offshoot or bud precedes the death of the older leaves (fig. 1).

It appears from the investigation and observations thus far carried on that the manner and place of infection largely determine which of these two types will occur. The infection may take place at the base of the offshoot, near the place where it joins the mother palm, and may prevent sufficient water from reaching the young leaves.

It may also take place in the outside leaves of the offshoot first, and may spread later to the newer leaves and to the heart.

The ventral mid-portion of the stalks, the part most commonly affected in the older palms, shows yellowish-brown streaks running upward from the base, and ranging in length from 6 inches to 3 or 4 feet (fig. 2*A*). The disease may spread laterally from one leaf base to others in close proximity. Frequently, these streaks extend upward on one of the lateral angles of the leafstalk. Such leafstalk streaks

Fig. 1.—*Diplodia* disease of date palms: *A*, dissected offshoot showing decayed, blackened center, and surrounding leaf bases killed back from tips; *B*, central pinnae showing black discoloration and fruiting bodies of *Diplodia*.

sometimes extend upward long distances, while the upper portion of the leaf is still normally green and apparently unaffected. The color and size of the streaks vary according to the age of the leaves. On a leaf that is still green the streaks may be 3 to 4 inches wide at the base, narrowing rapidly upward to a width of ½ inch or less. The outside color near the base may be pecan brown to terra cotta.[22] On a cross section (fig. 2*B*) the tissue may be chestnut brown to raw umber at the center and cinnamon buff on the edges, where the tissue has been more recently involved. On a large leaf these brown streaks may extend as much as 4½ feet from the base, and yellow streaks may extend 2½ feet beyond this point.

The Causal Fungus.—A fungus to which we are assigning the name *Diplodia phoenicum* (Sacc.) n. comb. has been repeatedly isolated from diseased lesions on leaf bases and dying offshoots. The fungus occurs generally in the Coachella Valley and has been isolated from at least eighteen date gardens in that section as well as from several localities in Arizona. A similar fungus was also isolated from specimens found in Tunisia.

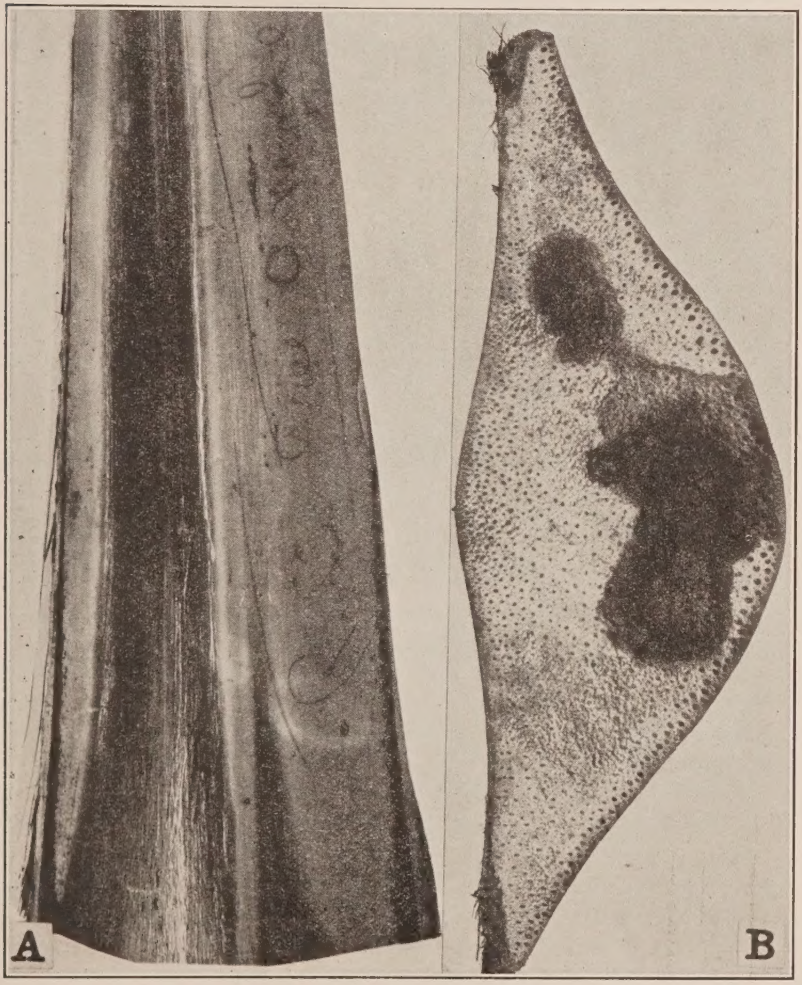

Fig. 2.—*Diplodia* disease: *A*, leafstalk of date palm showing discolored streak extending up from base at the ventral mid-portion (about ½ natural size); *B*, cross section showing region of dark brown tissue in the interior of a leafstalk invaded by *Diplodia* (about natural size).

Although the spores of this fungus are about the same size as those of *Diplodia natalensis* Evans, which produces stem-end rot of citrus in Florida and California, the fungus has somewhat different growth characteristics. Moreover, it has not been found attacking fruits or the bark of grapefruit trees interplanted with date palms in the date gardens of the Coachella Valley. The most common and abundant spores in cultures or on dead tissues are hyaline, unicellular, and *Macrophoma*-like (fig. 3*a*). We have assumed that this most common stage of the fungus was described by Saccardo as *Macrophoma phoenicum*.[4] The hyaline spores may become dark and septate later (fig. 3*b*) and, therefore, the name *Diplodia phoenicum* (Sacc.) should be assigned.

The dark, bicellular spores (occasionally tricellular) (fig. 3*b*, *c*) measure 22 to 24 μ by 10 to 12 μ. The light-colored unicellular spores are somewhat larger than the mature ones. The most striking difference between this fungus and *Diplodia natalensis* as found in cultures from citrus fruits in Florida and California is the formation of dark, intercalary chlamydospores in great abundance by the date fungus.

The pycnidia have not been found commonly on the leaf bases of the older palms while they are still alive and attached to the tree under conditions in Coachella Valley, but they have been found commonly on dead leaf parts at certain times (fig. 4). They are formed also on inside protected dead leaves of dying offshoots; and, if the stained interior tissue of the lesions on leaf bases is placed in a moist chamber, pycnidia are formed on the surfaces.

Varieties Affected.—The Deglet Noor was the first variety on which the disease was observed and studied, but many other varieties are also affected, although not all in the same manner. In some varieties, instead of advancing along the ventral mid-portion, the fungus extends along one lateral angle of the leafstalk. In the Saidy variety the large swollen bases of the fronds are frequently rotted away completely by *Diplodia* and secondary organisms, causing the leaves to break off easily. The varieties in which typical *Diplodia* symptoms have been found in California are Saidy, Deglet Noor, Hayany, Menakher, Baklani, Rogani, Shukkar, Besser-Haloo, Horra, Halawi, Khastawi, Thoory, Zaheedy, Tazizaoot, Hassan-Effendi, Ret-Bet-Regaia, and Iteema.

Contributing Conditions.—Observations indicate that although wounds made in pruning contribute to infection leading to the development of the disease, such wounds are not always necessary for infection, especially in the case of offshoots. For example, in one Deglet Noor garden where the disease is doing much harm to offshoots, no pruning of leaves on either the mother trees or their offshoots has ever been done except when cuts were made in removing offshoots from

[4] Specimens containing this stage only were identified by C. L. Shear, Bureau of Plant Industry, United States Department of Agriculture, as *Macrophoma phoenicum* Sacc.

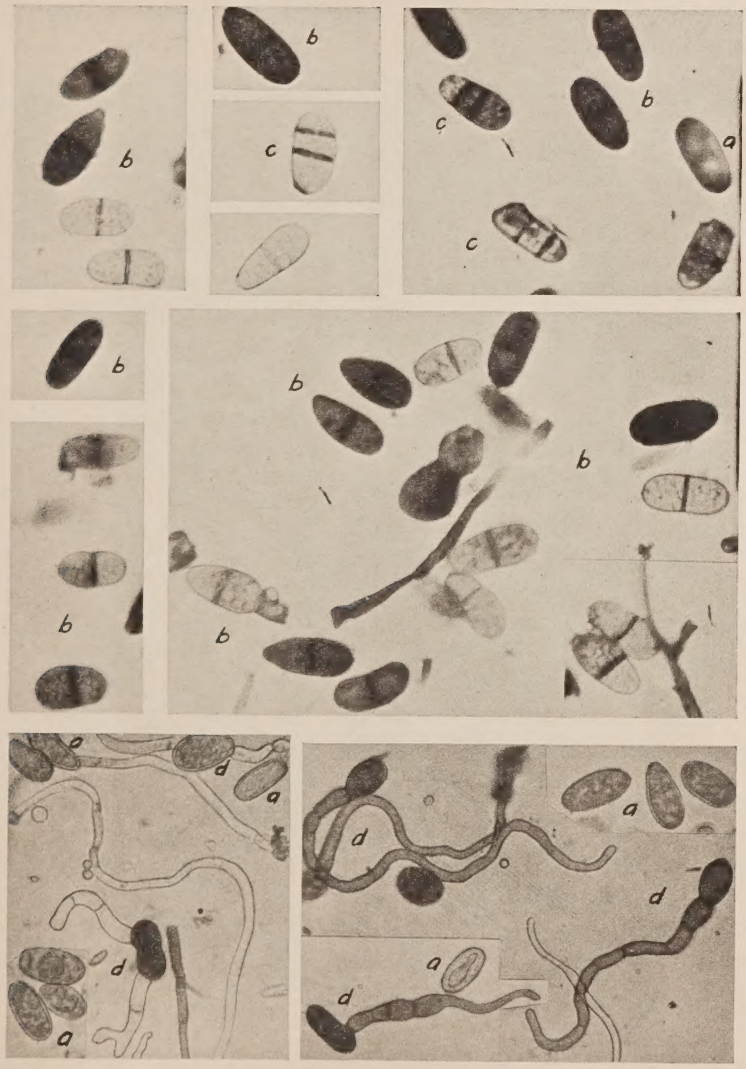

Fig. 3.—Photomicrographs of various forms of *Diplodia phoenicum* spores: *a*, unicellular *Macrophoma*-like hyaline spores; *b*, bicellular *Diplodia* type of spores; *c*, occasional tricellular spores (approx. x 1,000); *d*, germinating spores (approx. x 640).

the mother palms for planting. These trees are growing in good soil and have been growing very rapidly as the result of adequate fertilization and irrigation.

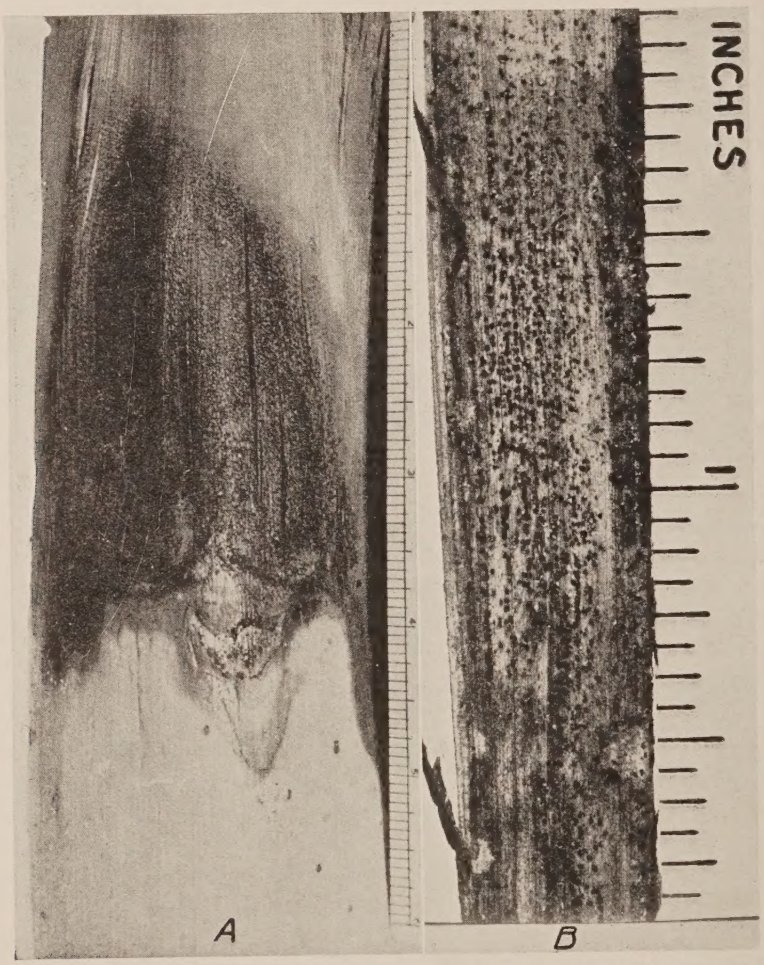

Fig. 4.—*A*, Pycnidia of *Diplodia phoenicum* on leaf base of date offshoot; *B*, enlargement showing pycnidia with spore tendrils. These contained mostly *Macrophoma*-like spores with a few *Diplodia* type of spores.

Many growers have assumed that dying of offshoots under such conditions is due to 'crowding off' by the very rapid growth of the palms. It is possible that in some cases this rapid growth may produce a strain on the union between the offshoot and mother palm,

causing cracks in which infection could take place more readily. This point has not been sufficiently investigated. The type of the disease which begins first in the outer leaves, either of the offshoots or of the older palms, appears to be aided by wounds. Another condition that may contribute to the disease is severe defects in irrigation where main roots may be accidentally allowed to dry out and die back. Such accidental defects in irrigation practice have been reported in some of the gardens where the disease was most prevalent on the leaves of older palms. A number of other organisms also have been found which are probably secondary, but some of them may aid in increasing the severity of the disease. The principal fungi sometimes found associated with the *Diplodia* are *Penicillium roseum* Link, *Aspergillus niger* v. Tiegh., and species of *Fusarium*, *Rhizopus*, and *Verticillium*.

Experiments for Control.—Some experiments were made to determine the efficacy of dipping *Diplodia*-diseased offshoots in various disinfectants prior to planting in the nursery or field. The disinfectants tried in a preliminary experiment were: a 10–10–50 wet bordeaux mixture, ammoniacal copper carbonate, a bordeaux dust, 1 per cent solutions of Arrow carbolineum, potassium permanganate, and copper sulfate, and 2 per cent solutions of formalin and licresolis. All the offshoots used showed evidence of *Diplodia* infection. They were immersed in the solutions up to but not including the bud. In the case of the bordeaux dust, a very thorough coating of the material was applied.

None of these treatments seemed to injure the offshoots, all of which eventually became established in the nursery row. Those dipped in the copper materials (ammoniacal copper carbonate and bordeaux) were the first to put out new leaves, suggesting a stimulating effect.[17]

Five hundred diseased offshoots were later dipped in ammoniacal copper carbonate solution (5 oz. copper carbonate dissolved in 3 pints of ammonia in 1 gallon of water and then diluted to 50 gallons) and planted in the field. Only 15 per cent of these offshoots failed to establish themselves, which, considering that they were diseased, was a good average last season when many growers were losing 25 per cent or more of the plantings.

Suggestions for Prevention and Treatment.—Careful attention to the proper use of water is suggested as a partial prevention, since there is an indication that the injury from this disease, especially in the case of leafstalks, is greatly emphasized by the results of defective irrigation, such as drying out and death of some of the main roots during dry hot periods.

Infection may readily enter surfaces cut by tools in pruning off the leaves or in removing offshoots. Therefore, it is a wise precaution to treat all pruning tools and cut surfaces with a disinfectant. One date grower has had good results in the use of a mixture containing 2 per cent commercial formalin and 98 per cent water. As much as possible of any dead functionless tissue on the offshoots should be removed.

A thorough spraying of date palm trees is recommended for further prevention of *Diplodia* infection. The spraying may be done with ammoniacal copper carbonate each year just after the fruit is harvested.

THE DECLINE DISEASE

The decline disease was first noted in the Coachella Valley about 1921. Its cause is not definitely known, but is thought to be related in some way to the nature of the soil. It usually occurs only in limited areas in certain orchards. These areas of diseased palms usually begin with only one or two palms and enlarge year by year until definite limits appear to be reached. One such area began in 1921 with one tree and enlarged as follows: 1922, 3; 1923, 5; 1924, 12; 1925, 18; 1926, 25; 1927, 28; 1928, 31. In three years since 1928 no new cases have appeared.

Symptoms.—The first symptoms noted are retardation of growth, lack of green color, and reduction in quantity and quality of fruit (fig. 5). Entire lack of fruitfulness eventually occurs, even to the extent of failure to produce any flowers. The symptoms are not clear-cut, and in the early stages it is difficult to determine whether or not a palm has the decline disease. No definite characteristic lesions have been found. The internal tissues of the stems of palms so affected appear to be sound.

The brown streaks of *Diplodia* disease on the leaf may be found on some decline trees, but since other trees badly affected with decline disease may show no *Diplodia* streaks, these streaks are not to be considered a symptom of decline.

Many of the roots of these affected palms are found to have deteriorated and died, and brown patches may be found on those still alive. Some of these same patches are also commonly found on sound roots of healthy trees. As high as 90 per cent of the roots may be dead on some palms that are badly affected with decline.

Certain palms affected with decline disease, as well as offshoots from such palms, have been removed from diseased areas to other

areas in the same gardens. After a time these transplanted palms have recovered and become healthy normal trees. This observation suggests relation to a soil condition.

Some Chemical Changes in Pinnae and Fruit Accompanying Decline Disease.—Investigations by Haas and Klotz[13] show that diseased

Fig. 5.—Palm in late stages of decline disease, showing absence of fruit stalks and premature death of outer leaves.

pinnae are lower in carbohydrates, total nitrogen, potassium, and phosphorus, but higher in calcium than the healthy pinnae. There were no appreciable differences in the sodium, magnesium, total sulfur, and total chlorine of diseased and normal pinnae.

Limited analyses of the fruit pulp from healthy and diseased palms showed that, when calculated on a dry-matter basis, the former

contain more potassium than the latter. However, the calcium and magnesium contents of the two groups were very similar in the few samples analyzed.

Experiments in Control.—With a view to finding a practical remedy for decline, the Citrus Experiment Station, in cooperation with dependable date growers, is now conducting extensive trials on soil treatments and injection of palm stems in five gardens in the Coachella Valley. Various fertilizers, amendments, and other chemicals have been added to the soil around the palms in these representative gardens. Other palms have been injected respectively with solutions of boric acid, with solutions and fine crystals of copper sulfate, and with solutions of manganese sulfate, potassium chloride, magnesium nitrate, and ferrous sulfate.

Based on the indications of growth stimulation and recovery it is suggested that for a palm 12 to 20 years of age or older, 50 to 75 pounds of copper sulfate (younger palms should receive correspondingly small amounts) be applied to soils in the Coachella Valley in the following manner: The copper sulfate in a fine crystalline form should be disked into an area approximately 28 feet square around the palm. An irrigation basin of the same size should then be made and water admitted for dissolving the chemical and carrying it to the roots. The results indicate that application during either December or January is probably most efficacious. Several palms thus treated have shown much progress toward complete recovery from the disease.

Some of the other treatments are showing promise, but the experiment has not progressed sufficiently to justify any further recommendations. The observations also indicate that gardens kept in a high state of fertility by the regular application of large quantities of fertilizers are less apt to have decline-diseased palms.

BLACK SCORCH

Black scorch was noted on emerging leaves in the Coachella Valley in 1927. Later, S. C. Mason stated that he remembered seeing this effect on emerging leaves of the Amhat variety at Indio as early as 1914. Black scorch was first shown by Klotz[17] to be due to the fungus *Thielaviopsis paradoxa* (De Seynes) v. Höhn.[5] in 1930. The disease occurs not only on emerging leaves but also in connection with a rot of the inflorescence[19] and has been found associated with the

[5] Identified by J. A. Stevenson, Office of Mycology and Disease Survey, Bureau of Plant Industry, United States Department of Agriculture.

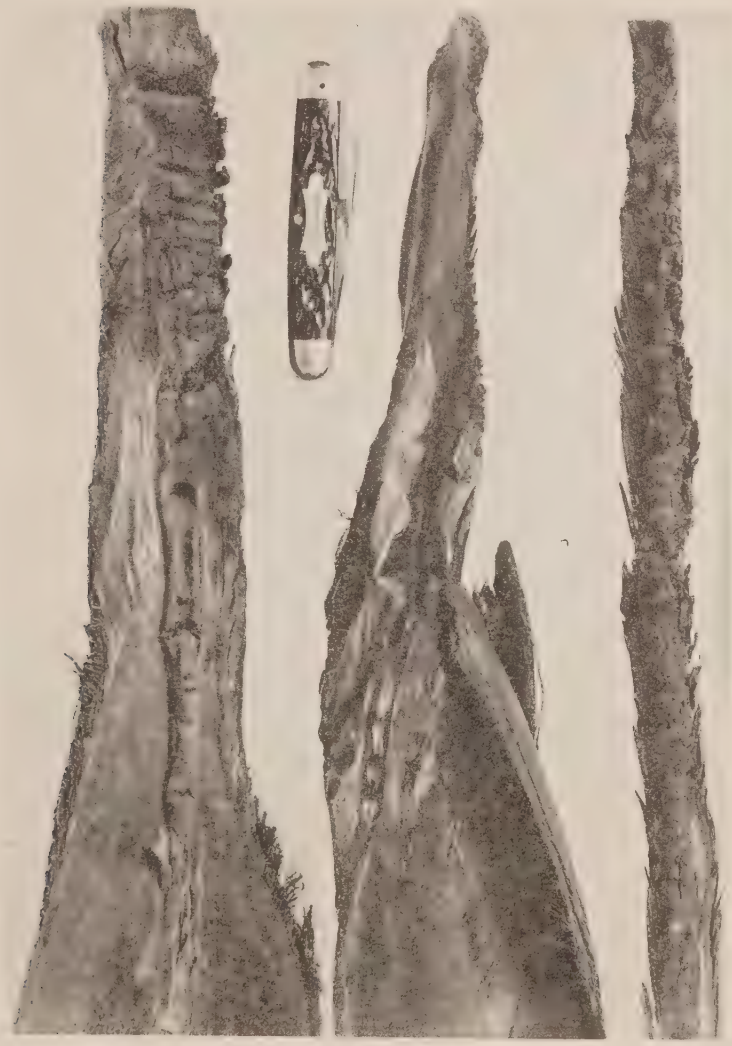

Fig. 6.—Date leaf bases, showing hard, black, rough, irregular decay due to black scorch fungus.

Medjnoon or 'fool' disease. Inoculations have shown that the causal fungus is capable of advancing rapidly in the tissue of leaf bases, stems, and roots of the date palm.

In addition to Coachella Valley, localities in the Southwest in which black scorch has been found are Riverside and Bard in California, and Yuma, Parker, and Salt River Valley in Arizona. The black scorch lesions with spores of *Thielaviopsis* were also found on

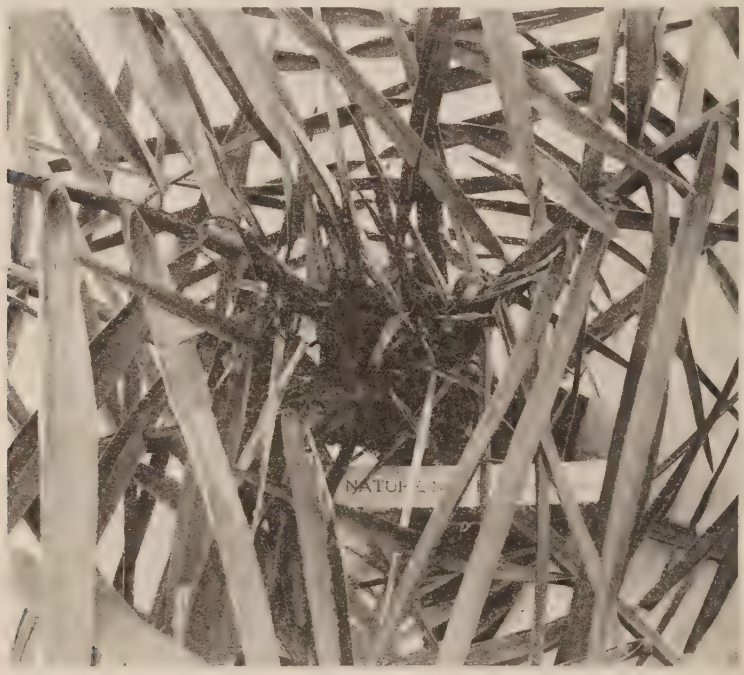

Fig. 7.—Large date seedling with the main bud killed and blackened by the black scorch fungus (artificial inoculation).

leaf bases at Fayum, Egypt, by Fawcett[12] in 1930. Other specimens suggestive of black scorch were collected at Tozeur, Tunisia, and Bou-Saada, Algeria. Specimens of blackened inflorescence on which spores of the fungus were found, were collected near Alexandria, Egypt.

Symptoms.—The most striking symptom of black scorch is a dark brown to black, irregular, rough, necrotic condition along the side of a leafstalk. The diseased areas give the impression that they might have been scorched by the heat from a torch or blackened by some strong chemical (fig. 6). In severe cases it may result in the warping

or distortion of certain leaves as they emerge, and a few cases have been found where the central bud has been killed (fig. 7). In California, the disease has been found associated with the 'fool' disease, in which the central stem turns at an angle to the vertical instead of continuing straight upward (fig. 10). Only an occasional plant is affected in this manner. The most frequent cases of black scorch seen on leaf bases are minor in their effect. These lesions are often limited to dry, dark brown, or black superficial layers of tissue on the angles of leaf bases and appear to have had no appreciable effect upon the growth of the leaves. In the Thoory variety this effect is especially common.

Klotz and Raby[19] have also found the disease connected with a blackening of the inflorescence and fruit stalk (fig. 8). In this form it resembles somewhat the Khamedj disease in North Africa, but the fungus is quite different. In both diseases the young inflorescence is diseased before the spathe opens. In black scorch, circular to elongated lesions occur, which are sorghum brown on the exterior surface of the spathe and range from this color to mahogany red or bay on the interior surface. The young fruit stalk within the spathe bears depressed, brown to black necrotic areas which are circular to oblong in outline. The fruit strands and the flowers of the young inflorescences are partly (fig. 8*B*) or completely blackened. Young strands of the fruit bunches that are attacked a little later in their development may show blackened, depressed lesions similar to those on the fruit stalks and some may be completely severed by the decay (fig. 8*A*). Soon the affected tissue becomes dry and firm and the areas bear black, powdery spores which distinguish it from the Khamedj, which has white powdery spores.

Varieties Affected.—The disease was first found on the Deglet Noor variety, but it has since been noted on all of the date palm varieties now grown in the Southwest, with the exception of Tazizaoot. Certain strains of the Thoory variety appear to be especially subject to this disease, as it occurs on emerging leaves. Observations suggest that in emerging, the leaves of this variety are bound by strong fibers more tightly than in other varieties and this pressure during the emergence may cause injury to the tender tissue that would subject it to infection by the black scorch fungus. Other varieties which also appear to be more subject to this disease than Deglet Noor are Hayany, Amhat, Saidy, and Halawi. Others on which it has been observed are Zaheedy, Menakher, Baklani, Gantar, Fteemy, Besser-Haloo, Nakleh-Zian, Kush-Shehan, Horra, Koroch, and Mub-Sali (male seedling).

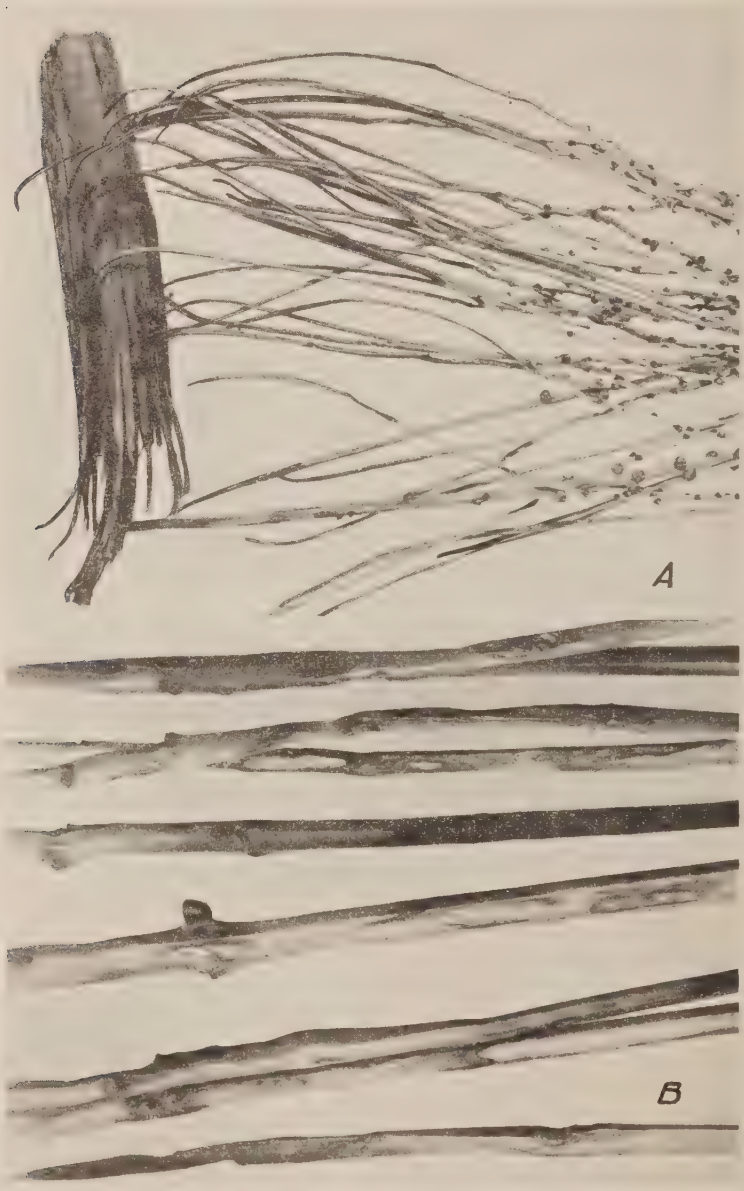

Fig. 8.—Diseased female inflorescence: *A*, fruit strands completely severed by attack of black scorch fungus; *B*, detail of fruit strands showing lesions (about natural size).

The Causal Fungus.—The pathogen (*Thielaviopsis paradoxa*)[6] responsible for the disease is one of a large group (the Hyphomycetes) of the so-called imperfect fungi which have not been found to reproduce by gametes. The spores of this group are borne on the ends of specialized vegetative hyphae called conidiophores. In this particular fungus the spores or conidia are formed internally, that is, within the conidiophore, the protoplasm simply dividing by forming cross walls (fig. 9). The ends of the new cells thus formed round up forming a chain of conidia which are extruded from the conidiophore. The long chains of spores readily break up into small groups and individual conidia, thus facilitating wind distribution. Two types of spores are produced: the cylindrical, hyaline microconidia, measuring 5 to 15 μ in length and 3 to 7 μ in width; and the macroconidia which are dark brown and egg-shaped and measure 11 to 17 μ in length and 7 to 15 μ in width. There are all gradations in size, shape, and brown color between these two types.

In germinating, the spores send out germ tubes which penetrate and grow inside the host cells. The hyphae of the fungus and the gum that forms during the invasion may become so abundant in the water-conducting vessels and surrounding cells as to interfere seriously with the transpiration stream and cause a wilting of the pinnae several feet beyond the pathological tissues.

Isolation and Inoculation Experiments.—Many successful isolations of the causal fungus have been made from diseased tissues of leaf bases, leaf pinnae, fruit stalks, and inflorescences. Inoculations have shown that this fungus is the causal agent of the black scorch disease. The details of these experiments are being published by Klotz and Fawcett.[18] Only the following brief summary will be given here:

1. In the greenhouse, inoculations were made by placing spores and mycelium of the fungus between the newest leaves of a date palm seedling 4 or 5 years of age. The inoculations resulted in brown spotting, which later turned black. Necrosis of the young leaves and pinnae prevented further development of new leaves. From resulting lesions which were characteristic of black scorch, pure cultures of the same fungus were again isolated.

2. On March 12, 1931, injections of a suspension of spores into an unopened spathe resulted, after 3 weeks, in infection and blackening of certain strands of the inflorescence, from which the fungus was recovered.

3. On February 11, 1931, inoculations made in leaf bases of large offshoots resulted, in one month, in the decay and falling-over of the leaf due to partial breakage at the place of inoculation. From these lesions the fungus was reisolated 18 inches from the point of inoculation.

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[6] Dade has found a fungus of the genus *Ceratostomella* which he considers to be the perfect stage of *Thielaviopsis paradoxa;* the name of the organism would thus become *Ceratostomella paradoxa.* (Dade, H. A. *Ceratostomella paradoxa,* the perfect stage of *Thielaviopsis paradoxa* [de Seynes]. Trans. Brit. Mycol. Soc. 13:189–194. *3 pl.* 1928.)

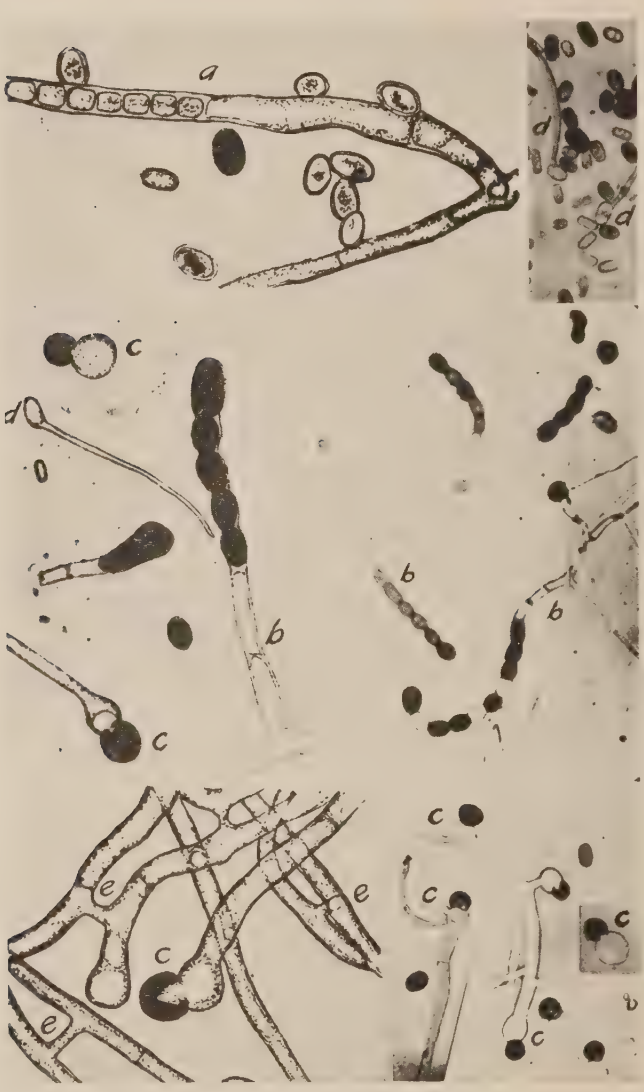

Fig. 9.—Black scorch fungus: Right, photomicrographs; left, tracings of photomicrographs, showing: *a*, microconidiophores with endogenous hyaline conidia; *b*, macroconidiophores with fuscous macroconidia; *c*, macroconidium germinating; *d*, microconidium germinating; *e*, anastomosing hyphae. (Photographs approx. × 200; tracings approx. × 400.)

4. On March 13, 1931, inoculations made on cut-off ends of leaves on large offshoots resulted in the rapid decay and dying-back of the tissue below the cut, while cut-off leafstalks not inoculated remained green up to the cut.

5. Inoculations in wounds in the base of palm stems caused the wilting of the leaves in about 4 weeks and formed a large water-soaked region 4 inches or more in diameter and extending several inches down on some of the roots.

Contributing Conditions.—While the fungus makes its swiftest progress in the young developing tissues of the date palm, it may also readily destroy mature tissues during favorable conditions. As already pointed out, liquid moisture is necessary for germination of the conidia and a temperature near 25° C is required for the most rapid extension of the mycelium. The high temperatures of summer undoubtedly check the malady.

Wounds, such as thorn punctures and V-cuts, facilitate the establishment of the disease, but wounding was shown to be unnecessary for successful infection of the petioles, pinnae, and roots of six-year-old seedlings. Likewise the uninjured inflorescences and roots, 12 mm ($\frac{7}{16}$ in.) in diameter, of twelve-year-old palms were readily invaded by the organism.

Suggestions for Prevention.—Since the cause of the disease has been so recently ascertained there has not been time for carrying out experiments on prevention or treatment. As has been pointed out, the effect on the inflorescence is similar to that produced by the Khamedj disease in North Africa. The following treatment, based on the measures used in the control of Khamedj, may be suggested for trial until there is time for further experimentation: Dry, powdered bordeaux is sifted in between the leaf bases, especially in the region where the future buds will push up. The first treatment may be made soon after the fruit is harvested and the second before any of the spathes have pushed up. Badly contaminated spathes, petioles, etc. may be removed and burned, and wounds and adjacent healthy tissues protected by some fungicide, such as dry bordeaux.

TERMINAL BUD ROT AND MEDJNOON OR FOOL DISEASE

The fungus (*Thielaviopsis paradoxa*) of the black scorch disease has also been found associated with a decay of the heart bud of date palms.[17] Having gained entrance to the succulent tissue of the bud region the disease progresses very rapidly. The entire terminal bud and adjacent leaf bases may succumb, eventually presenting a dried,

dull, blackened, charcoal-like appearance. Two large date seedlings in boxes in the greenhouse were killed by inoculations at the base of the young central leaves. In four of the five cases observed in the field the entire bud was not killed, but grew out laterally, producing the so-called 'fool disease' effect. The name fool disease comes from the Arabic equivalent Medjnoon. It is applied to any condition which causes the terminal bud to grow out laterally instead of vertically (fig. 10.1). It is believed that *Thielaviopsis* is the principal organism responsible for this peculiar trouble in the Southwest. In three or more years, according to the extent of the injury, the entire bud

A *B*

Fig. 10.—Medjnoon or fool disease showing: *A*, terminal bud growing laterally, owing to attack of black scorch fungus; *B*, partial recovery of same tree as indicated by the almost vertical position of the terminal bud.

may regenerate from the uninjured portions of the meristematic tissue and returns to its normal vertical position (fig. 10*B*). High temperatures and the resulting rapid growth of the palm may be the factors operating to prevent the disease from terminating fatally in all instances.

In Tunisia, where it is estimated that only about 1 per cent of the trees are affected in this way, no definite reason is known for this peculiar behavior of the palm. Whether or not the same causes are responsible in northern Africa as in California has not been determined. The method employed by the Arabs and French in curing such trees was to cut off all leaves close to the trunk up to the bud, pulling away all the fiber. Usually after such treatment the bud will resume vertical growth.

INFLORESCENCE DECAY

The decay or molding of the inflorescence before it comes out of the spathe by *Thielaviopsis paradoxa* has been discussed under black scorch. Other fungi have been found in partly decayed or molded spathes, as *Diplodia phoenicum* (Sacc.) and *Fusarium*. *Fusarium* sp.

Fig. 11.—Inflorescence decay: *A*, attack by *Diplodia* and *Fusarium* (spathe removed); *B*, by *Fusarium* (portion of spathe removed).

is sometimes found mixed with either *Thielaviopsis* or *Diplodia*, or it may be alone (fig. 11). Inoculations with spores of both *Fusarium* sp. and *Diplodia phoenicum* separately and in combination into unopened spathes showed them capable of doing some injury, but not nearly so great as that due to *Thielaviopsis paradoxa*. As S. C. Mason has pointed out in conversation, there is often a small opening at the distal end of the spathe through which spores or mycelium might enter.

V-CUTS AND CROSSCUTS IN LEAF BASES

V-shaped notches in the leaf bases and crosscuts which all but sever the midrib are frequently found (fig. 12). They often result in a breaking or bending at the base so that the ends of the leaves

Fig. 12.—V-cuts on leaf bases.

are resting on the ground. Where even the smallest living connection was maintained the leaf remained green and in an apparently healthy condition; in fact several of the affected leaves seemed more vigorous

than unaffected leaves in the same whorl on the same tree. The downward passage of elaborated foods was evidently prevented in a large measure. No fungus or insect pathogen was found to be connected with this trouble. It is thought that these injuries probably originate mechanically at a very early stage in the development of the rapidly expanding, tender fronds near the bud of the tree or offshoots. A small rupture in the tender tissue due to binding by the fiber and pressure of rapid growth, and possibly twisting due to winds would probably develop into the crosscut and V-cut injuries as we find them later in mature tissue. Such cuts were found in as far as the fourth whorl of leaves from the center; these were clean and showed no necrosis. The black scorch trouble has frequently been found associated with the crosscuts and V-cuts, suggesting that the injuries probably are the points of entry of the fungus.

GRAPHIOLA LEAF SPOT

Graphiola leaf spot, also called false smut, is due to a fungus, *Graphiola phoenicis* Poit., related to the smut fungi.[15] It attacks the leaves, producing numerous pustules. It appears to be world-wide in distribution. It is present in Maricopa and Yuma counties in Arizona, and in San Diego County and coastal sections of California, but has not been found as yet in the Coachella Valley, California. It is found in sections bordering the Mediterranean wherever the climate is not excessively dry. It does not seem to exist in the oases of the Sahara Desert. Observations in Egypt indicated the pustules were most abundant on date palms in the lower part of the delta region and were less common but still present in the upper delta and at Fayum. In the oases in the Libyan Desert it is said to be absent. This disease is not considered very serious or dangerous in any of the countries where it exists. In Egypt the pustules appeared to be conspicuous only on the older, lower leaves, and the close trimming of the leaves apparently keeps the disease down to a point where little injury to the trees resulted.

Symptoms.—The disease occurs on the pinnae of leaves in the form of small, cylindrical pustules with a dark brown or black envelope from which yellow spore dust escapes. These pustules (fig. 13) are about ½ to 1 mm (1/50 to 1/25 in.) in diameter and protrude from the surface of the leaf. The leaf tissue immediately surrounding the pustule is often yellowish in color, and parts of the pinnae may dry out when the pustules are numerous.

Control.—No control measures, except cutting out the old, badly affected leaves, appear to be commonly practiced.

R. B. Streets of the Arizona Agricultural Experiment Station is publishing the results of an investigation of this disease in Arizona, and we have his kind permission to publish the following statements, based on his manuscript.

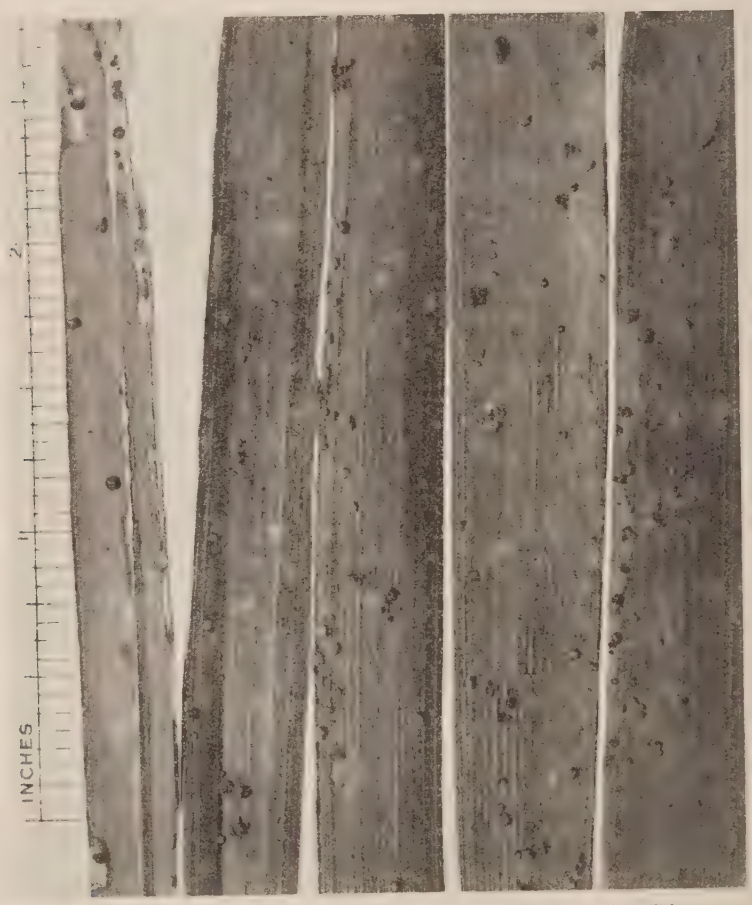

Fig. 13.—*Graphiola* leaf spot, showing pustules of *G. phoenicis*.

The *Graphiola* leaf spot may be severe in unpruned plantings but is not likely to become serious in orchards that have good care. Pruning of badly affected leaves on the large trees so as to insure free air movement may reduce the disease to a few pustules per leaf. Pruning followed by careful spraying just preceding the development of the new crop of spores (which in the Salt River Valley is usually in early May) was very satisfactory and gave almost perfect control.

Either bordeaux mixture, 4–4–50, with a casein spreader; or copper acetate, 3 ounces to 50 gallons, with a casein spreader, was found to be effective. The latter had the advantage of being practically colorless when sprayed on foliage and fruit.

BROWN BLOTCH

A spot on midribs and pinnae of leaves, which we are naming "brown blotch," has been noted especially in the Salt River Valley, Arizona. A similar spot has also been noted in California. It resembles somewhat a spot in North Africa, referred to later.

Fig. 14.—Brown blotch on pinnae and midrib of leaf.

The spots vary in size. They may be ½ inch to 1 inch or more in length, with somewhat irregular outlines (fig. 14). They are light brown at first and later become dark brown to black. The spots are somewhat superficial at first, but later some of the underlying tissue is discolored.

A slow-growing hyphomycetous fungus has been isolated from these spots, but its identification has not been possible so far. Its type of growth on glucose-potato agar is somewhat similar to that produced by the citrus scab fungus, but it cannot be considered at present to be necessarily related to that fungus.

DRY BONE DISEASE

Dry bone is a disease of minor importance, thought to be due to a bacterium which has been repeatedly isolated from the lesions, but which has not yet been studied. The disease has been found generally distributed in California and Arizona and was observed[12] in Egypt, Tunisia, and Algeria in 1930.

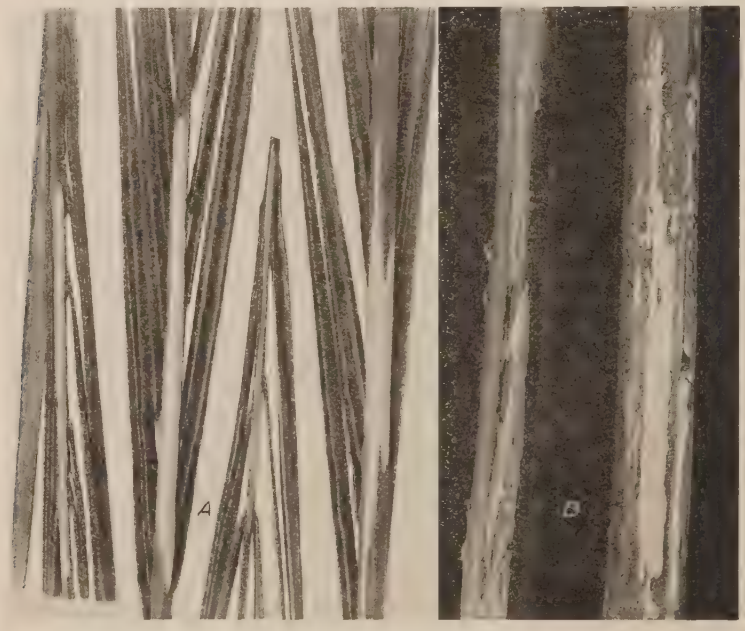

Fig. 15.—Dry bone on leaves: *A*, fresh lesions on young leaves; *B*, older lesions showing dried cracked tissues.

Symptoms.—Dry bone is characterized by whitish, irregular blotches and streaks on the leafstalks, midribs, and pinnae (fig. 15). It affects the epidermis and only a thin layer of tissue, and as a rule does not appreciably affect the health of the leaves. There appear to be great differences in susceptibility, and occasionally an individual palm is found which is badly spotted and blotched by the disease. The spots, blotches, and streaks are variable in size, being from ¼ inch to several inches in largest diameter. With age they become definitely outlined and may or may not have a reddish brown margin. The surface dries and presents a hard, smooth, white appearance, suggestive of the name 'dry bone' given to it by S. C. Mason. If the outer white layer is carefully removed one often finds that the reddish brown margin actually marks the boundary of a lower dark layer of the same color. A bacterium is present in the early stages, but apparently dies out as the affected tissues dry out, and the spots become self-limited.

FRUIT SPOTS, ROTS, AND OTHER DEFECTS

Under the ordinary conditions of dry weather in the date-growing districts of the Southwest, little trouble is experienced with the fruit until after it is full-sized, and then only if rains or very humid conditions occur. Untimely rains and moist weather just preceding and during the harvest are very disastrous because of the accompanying decay and spotting of the fruit. The injurious effects of rain on dates in Tunisia have been fully pointed out by Kearney.[14] Rains that occasionally occur in the Coachella Valley during the ripening period of the fruit are very destructive, causing cracks in the dates and exposing the inner saccharine flesh to fungi. (See fig. 21.) Several fruit-rotting fungi are known to flourish during such times, and there is some evidence indicating that blacknose, a physiological trouble, originates under similar conditions (see "Blacknose," p. 35). Also, cracking of the cuticle and flesh of Deglet Noor date fruit in the late khalal[7] stages takes place if the dates are kept wet or in a saturated atmosphere continuously for two or more hours, as described later.

With the possible exception of *Alternaria* and *Helminthosporium* all the fungi found causing fruit decay are wound parasites. Protection of the bunches of fruit by burlap or tough paper at the time of

[7] Stages of maturity in date fruit:
Khalal—fruit has changed from green to red or yellow.
Rutab—from beginning of softening to completely soft.
Tamar—cured to a point where fruit will keep.

ripening has been helpful in lessening losses from this source. Copper fungicides, such as bordeaux mixture, bordeaux dust, and ammoniacal copper carbonate, have been effective in inhibiting germination of the conidia of the fungi, and it may be feasible to spray or dust shortly after the dates reach full size. Flowers of sulfur and lime-sulfur were ineffective in preventing germination and growth of the fungi. Removal of the fungicides during the processing of the dates is a factor that must be considered. Removal of bordeaux dust by the brushing process given to the fruit when it is received at the packing house has not been tried. The ammoniacal copper carbonate

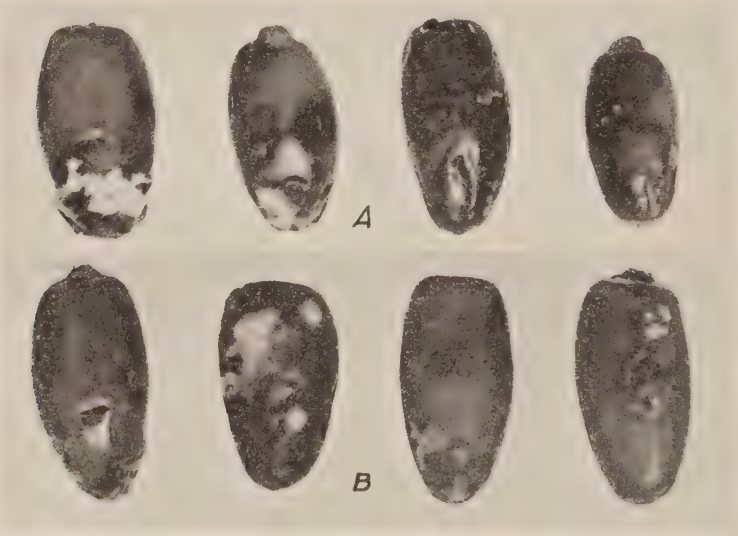

Fig. 16.—Brown spot of fruit: *A*, due to *Helminthosporium molle*; *B*, due to *Alternaria citri* (artificial inoculations).

leaves a residue that is practically unnoticeable and from this standpoint would be very desirable, although due to its small content of copper it is less effective as a fungicide than bordeaux mixture.

Brown Spot.—This spot, due to species of *Alternaria* and *Helminthosporium*, was first described by Brown[2, 3] of the Arizona Experiment Station. It occurs especially after rains or moist weather at or before the time of maturity. The Deglet Noor is especially susceptible.

The disease manifests itself as small opaque or translucent brown spots which enlarge, forming oval or circular darkened areas, near the center of which the fruiting bodies of the fungus appear (fig. 16). In the early stages the spot may be sufficiently firm to permit scooping out the affected tissue intact.

Brown[2, 3] describes its development in Arizona as often beginning with minute spots, water-soaked in appearance, enlarging and uniting to make a blister. After the formation of blisters, drying and mummification take place. Damage of up to 95 per cent of the crop has been experienced in a few cases.

This type of spot may be produced by the invasion of at least two different species of fungi. Brown[2, 3] worked with a species of *Alternaria* and a species of *Helminthosporium*, but did not identify the species. It is difficult to assign names of species in such genera. We find, however, that the *Alternaria* we have isolated in Coachella Valley produces spores in glucose-potato medium extremely variable in size and shape as indicated by figure 17*C*. In general, they are similar to the *Alternaria citri* Pierce which we have isolated from black rot of oranges. We are, therefore, tentatively calling this fungus *Alternaria citri* Pierce. The larger spores, which have at least three septa at right angles to the long axis and other septa parallel to the long axis, usually measure about 10 to 14 x 20 to 33μ (fig. 17 *B*, *C*). Inoculations of the *Alternaria* from date and from black rot of oranges have both produced the same type of spots on Valencia orange fruits.

While several species of *Helminthosporium* have been described on palms, the spores of none of them appear to have the same measurements as those of the species which we have isolated from date palm fruits. Isolations grown on glucose-potato agar produce spores mostly three septate and measuring about 8 to 12 by 27 to 33 μ (fig. 17*A*). The size of the spores and the description of the fungus seem to agree with those of *Helminthosporium molle* Berk. and Curt.[8]

Calyx-End Rot.—Another fruit trouble that may follow or accompany wet weather is the so-called 'calyx-end rot' due to *Aspergillus niger* v. Tiegh. and *Citromyces ramosus* Bainier and Sartory. That due to *Aspergillus* is a softening, rather indefinite in outline, that occurs at the calyx end of the fruit (fig. 18*A*). The fungus was nearly always obtainable in pure culture from the softened tissues. In several dates it was found sporulating in the seed cavity just under the dried remnants of the perianth or button. In the fruit inoculated by hand the organism grew all through the flesh causing a general softening rather than a definite spotting.

The fruit from low-hanging bunches, especially on young palms, is frequently of poor quality and breaks down more readily than the

[8] C. L. Shear of the United States Department of Agriculture Bureau of Plant Industry has kindly identified this fungus.

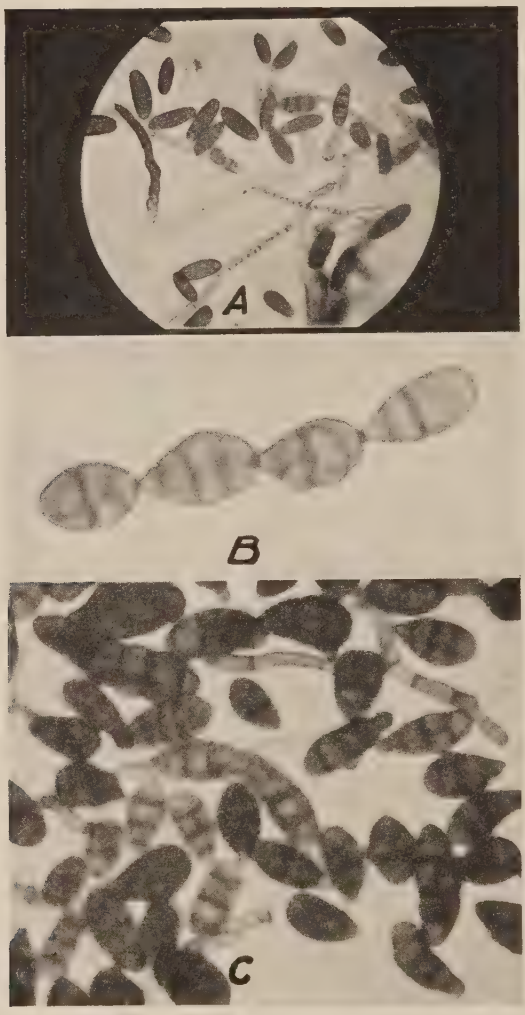

Fig. 17.—Fungi causing brown spot of date fruit: *A*, mycelium, conidiophores, and spores of *Helminthosporium molle* (approx. x 220); *B*, spores of *Alternaria citri* from date fruits in characteristic chain (approx. x 700); *C*, mycelium and spores of *A. citri* (approx. x 500).

high-hanging fruit on older palms. Young palms irrigated when the fruit is in the late khalal and early rutab stages may yield dates having a high percentage of a soft rot due to *Citromyces ramosus* B. and S. and to other wound parasites. The character of the decay due to *Citromyces* (fig. 18*B*) is very similar to that caused by *Aspergillus.*

Fig. 18.—Soft rot of date fruit due to: *A, Aspergillus niger; B, Citromyces ramosus* (artificial inoculations). Note that immature fruit on left resisted the attack of the fungi.

This type of decay is promoted by the cracks that develop in low-hanging fruit due to high humidities and to condensation water that collects on the fruit, exposing the rich inner tissue. Figure 21 shows the effects of high humidities and water on date fruit.

Minor Fruit Rots.—In the laboratory it was shown that in addition to the four organisms mentioned, which are the most prevalent decays of date fruit in the field, a number of other fungi will produce decay

Fig. 19.—Rot of date fruit due to *Catenularia fuliginea*.

in wounded dates in moist chamber. These include *Diplodia phoenicum* (Sacc.) Fawcett and Klotz, *Phomopsis phoenicicola* Trav. and Spessa., *Thielaviopsis paradoxa* (De Seynes) v. Höhn., *Citromyces ramosus* B. and S., *Penicillium roseum* Link, and *Catenularia fuliginea* Saito, all isolated from the date palm. None of the fungi appeared to be able to attack green fruit; only the fruit in the late khalal and more mature stages was susceptible. Fruit dusted with bordeaux dust, placed in moist chamber and inoculated broke down less rapidly than fruit not dusted.

The fungus (*Catenularia fuliginea* Saito) sometimes becomes troublesome on packed date fruit that has been cured by the so-called wet process. It grows very rapidly in the syrupy covering of the date, and sporulates in reddish brown, monilia-like cushions, rendering the fruit unfit for sale (fig. 19). A steam bath at a temperature of 95° to 100° C for 1 minute was found sufficient to kill the organism.

Blacknose.—Blacknose is an important trouble of date fruits. In appearance it is characterized by a darkening and a slight to severe cracking of the distal end of the date, involving as much as half of the flesh (fig. 20). These blemishes cause such a lowering of the grade that losses during some seasons are very heavy. The Deglet Noor, the principal variety grown in the Coachella Valley, is particularly susceptible to the trouble. It has been observed on other varieties, but a detailed survey has not been made as to its occurrence.

Pathological culture work indicates that no primary microörganism is responsible for blacknose and that it is probably of physiological or nutritional origin. A few determinations on stored fruits indicate that dates affected with the trouble contain a smaller amount of reducing sugars than normal dates, but have about the same content of total sugars. Chemical work now in progress on the inorganic constituents of blacknose and healthy dates and of susceptible and resistant varieties of dates should yield some clues as to the composition responsible for, accompanying, or resulting from the condition.

The several theories extant to account for the malady have been discussed briefly elsewhere.[17] By immersing Deglet Noor dates in the pre-khalal stage in water for various periods, Roy W. Nixon,[9] Associate Horticulturist at the United States Experiment Date Garden, Indio, has been able to produce apical cracks in the skin similar to those which precede and accompany blacknose. This gives some weight to the theory that showers and periods of heavy dews and

[9] Unpublished data. Similar recent experiments by Klotz and Haas have confirmed these results.

Fig. 20.—Blacknose of date fruits. One on lower left normal.

high humidities that sometimes occur in the valley at this stage of development of the date fruit might produce effects similar to blacknose.

Klotz[17] has already pointed out that the incidence of blacknose may be increased by bagging bunches of fruit and exposing them to the vapors of carbon disulfide or carbon tetrachloride. Bunches thus treated had 30 and 10 per cent blacknose respectively while the bagged bunch not treated had less than 1 per cent of the malady. Spraying and dusting with copper and sulfur fungicides had practically no effect on the occurrence of blacknose.

Cracking of the Fruit.—The effect of water and high humidities on Deglet Noor date fruits has already been mentioned under the discussions on *Aspergillus* decay, *Citromyces* decay, and blacknose. Dates in the khalal and early rutab stages, immersed 2 to 5 hours in water, developed many large cracks. Dates placed in a saturated atmosphere took up water and developed very severe ruptures, usually near the tip end (fig. 21).

Strands of dates were placed respectively in atmospheres with relative humidities of 0.0, 10.5, 21.5, 38.0, 49.0, 60.7, 70.4, 80.5, 89.9, and 100.0 per cent to test the effect of atmospheric humidity in the production of cracks. These humidities were obtained by employing sulfuric acid of various concentrations as described by Stevens.[23] Only in chambers having 100.0, 89.9, and 80.5 per cent humidity did cracks develop, and only a few developed in the latter two. The dates in these three atmospheres were rapidly covered by several species of *Penicillium* and *Aspergillus*. The fungi became less in evidence as the lower humidities were approached, there being none in the chambers at 0.0, 10.5, and 21.5 per cent humidity. At these lower humidities, a slight but distinct shrinking of the fruit occurred. This experiment affords a better understanding of the relation of rains, dews, and high humidities to fruit spoilage in the date gardens.[10]

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[10] Through cooperation with the Division of Plant Physiology, experiments with small lots of both attached and picked fruit have shown that it is largely possible to prevent cracking due to rains and high humidity by coating the dates in the late khalal stages with waterproofing materials such as mineral oils, paraffin, and cellulose solutions.

Fig. 21.—Cracking of date fruit: *A*, following immersion in water for 3 hours; *B*, due to atmosphere of high humidity.

DISEASES NOT FOUND IN CALIFORNIA OR ARIZONA

Certain diseases of date palms that have not been found in California and Arizona are described here not only as a matter of interest to date growers but also in order that they may be more readily recognized at their beginning should they by any chance be introduced. The literature of date palm diseases is mostly in the French language. The most recent and important publications are by Chabrolin[7, 8] and Maire and Killian.[20] Chabrolin[7] has compiled a good bibliography of the scattered date palm disease literature preceding 1930.

BAYOUD DISEASE

By far the most serious disease of date palms known anywhere in the world is the bayoud. This disease is now located in southern Morocco south of the Atlas Mountains and in a few cases in western Algeria not far from the border of Morocco. It is supposed to have originated in the southern portion of Morocco in the region of the Drâa and to have spread northward to Bou Denib and eastward to Figig, reaching in recent years some of the oases of western Algeria, such as Beni Ounif and Colomb Bashar. It has not been found in the important districts in central or eastern Algeria nor in any other date palm regions of the world.

The investigations and literature on the bayoud disease have been recently reviewed in French by Maire and Killian[20] and Chabrolin.[8] Swingle[26] was the first to publish an account of the disease in English, in which he pointed out its seriousness and its grave danger to other date-growing regions of the world. Dr. Swingle had been an unofficial member of the bayoud commission appointed by the French government in 1926 to make extensive observations as to the seriousness of the disease.

In February, 1930, Fawcett[12] studied this disease in the Figig district of North Africa in company with two French pathologists, Charles Killian of the University of Algiers, and Charles Chabrolin of the Agriculture College in Tunis. This was made possible by a joint arrangement between the Bureau of Plant Industry of the United States Department of Agriculture and the Citrus Experiment Station of the University of California. A fungus was found generally distributed in the affected tissues of the diseased palms, similar to one that had previously been isolated from the bayoud-diseased tissue, but not named. The fungus has been described since under the name of

Fig. 22.—Bayoud disease of date palm: early symptom indicated by whitening of some of the pinnae.

Cylindrophora albedinis by Maire and Killian.[20] Further investigation will determine whether this fungus is the primary cause of the disease or merely a secondary invader of the diseased tissue.

Symptoms.—It is difficult to describe this disease or to illustrate it with photographs so that one who has not seen it may get a clear mental picture of it. Usually (but not always) the first symptom to

Fig. 23.—Date palm killed by bayoud disease.

be seen is whitening or blanching of the pinnae of one leaf or several leaves (fig. 22). The first leaf affected may be situated anywhere on the plant from the center to the outside, but most often near the center. The whitening may often affect the pinnae on one side first (fig. 22) and such leaves soon dry out. Within six months or a year after this symptom appears the palm will usually wilt completely and die (fig. 23). No palm has been known to recover when once

attacked. Young palms are attacked by this disease, and also palms fifty to one hundred years old, bearing large quantities of fruit, are attacked one after another until large areas are completely killed.

Other symptoms accompany or follow the whitening and drying of the pinnae on certain leaves. Streaks or longitudinal bands occur on midribs and leafstalks which are at first just a little off-color, changing to light brown, then dark brown, and extending up from near the leaf base. When these streaks are visible on the exterior, a dark region will be found internally in which tissues are much discolored. In some leaves, a faint to dark stain is found well advanced and involving much of the interior tissue of the leaf bases and midribs before any sign is visible on the exterior. In trunks of diseased palms are often found pink discolorations extending in lines along the fibers, with tissue between apparently normal in appearance. These pink lines are usually one-sided and in line with diseased leaf bases. Roots of palms in early stages of the disease appear to be normal, without odor of fermentation or decay.

In some leaf bases affected by this disease one finds streaks that superficially resemble the streaks due to *Diplodia phoenicum*, but the bayoud differs markedly from the *Diplodia* disease in having more extensive stain of the internal tissues, in a more rapid advance of the malady, in showing the whitened pinnae and the pinkish lines in the fibers of the trunk, and in the quick death of older as well as younger palms.

Possible Mode of Infection.—In most cases observed at Figig and Beni Ounif the disease seemed to have originated above the ground on one side of the tree and then spread upward and sidewise. Chabrolin[8] mentions the infection through the leaves as one of several possibilities. Maire and Killian[20] mention the possibility of its spread by means of tools used in cutting off the leaves. Other possibilities are infections through the flower stalks or through roots, although observations do not favor the latter because the roots of recently diseased trees appear to be healthy.

Need for Investigation.—The menace from the possible spread of bayoud is of international importance. Since modes of infection and spread are not definitely known, a thorough investigation of this disease is needed as a basis for procedure to prevent its spread to other date-growing regions of the world.

As stated by Chabrolin,[8] since modes of contamination are not certainly known, the general control measures which might be suggested to prevent infection have uncertain value. The means that

seems to hold out some hope for the future for regions already attacked is to search for resistant varieties to replace date palms that have been killed. In localities like Bou Denib and Figig there are no varieties absolutely resistant. One of the best varieties, Medjool, is said by Swingle[26] to be very susceptible. Varieties such as Taabdount, Assiane, Asiza, and Bou-Slihan have been observed to have more resistance than most other varieties, but even these will not live when planted in the hole from which a dead palm has been removed. The natives of Morocco claim that in the oases of the Drâa district, in which many years ago all date palms were killed, palms are now growing which are resistant to the disease. If this information is correct it offers some hope of obtaining resistant varieties by search in such places, according to Swingle.[26] Killian, Chabrolin and Fawcett[12] agree that a research station should be established at some point where the disease is present, such as Beni Ounif or Figig, for an immediate investigation of these points. At such a station all possible varieties should be assembled from various date regions of the world in order that their resistance to bayoud could be tested.

KHAMEDJ

Khamedj is a disease of the inflorescence only and is due to a fungus, *Mauginiella scaettae* Cav.[5] This has recently been investigated and described in detail by Chabrolin.[6, 7] The khamedj is distributed in Cyrene, Tunisia, Algeria, Morocco, and Italy, and Chabrolin[8] believes it also exists in other countries of the Old World. Fawcett[12] observed it at San Remo and at Naples in Italy. Its absence in California and Arizona may be due to the fact that it attacks only the inflorescence and would therefore not be so likely to be brought in on offshoots to this country as would diseases which attack leaves.

In the khamedj disease the inflorescence is attacked before it comes out of the spathe. As described by Chabrolin,[8] the first visible symptom is a spot showing on the surface of the spathe. This enlarges as the fungus spreads over a greater part of the inflorescence inside. In severe attacks the spathe does not open and the contents finally dry out. If the inflorescence grows free from the opened spathe, the brown tissues dry out. The brown tissues are covered by abundant white powder produced by the spores of the attacking fungus. Infection is thought to take place through the spathe from the exterior without injury.

In his experiments, Chabrolin[7, 8] has obtained good control by means of powdered bordeaux dust which was sifted in by hand between the sheathes of the leaves in the region where future spathes would push up. Two applications are recommended—one after the dates are harvested, the other before flowering.

SOME LEAF SPOTS OF DATE PALMS IN MEDITERRANEAN COUNTRIES

In addition to the *Graphiola* leaf spot, several different leaf spots have been observed in Mediterranean countries. A spot commonly found was characterized by deep reddish brown, chocolate, or black spots on the leafstalks and mid-portion of the leaves. The spots were ¼ to 2 inches in greatest diameter, with indefinite, irregular margins. These spots affected only a thin layer of tissue. They were found in Egypt, Tunisia, Algeria, San Remo in Italy, and Nice in southern France. They are similar in appearance to the brown blotch which occurs in California and Arizona.

A fungus which appears to be a species of *Phoma* was found in this spot in Tunisia. The growth of the fungus on corn meal agar is eventually black with no aerial hyphae and with numerous pycnidia, 120 to 140 μ in diameter. The spores are nearly hyaline and about 5 x 3 μ. No inoculations were made.

On leafstalks and midribs, several kinds of spots were found. At Fayum, Egypt, on leafstalks, brown, oval spots occurred that were about 10 to 15 mm (0.4 to 0.6 in.) in longest diameter with pink tissue underneath, extending inward for about 5 to 10 mm (0.2 to 0.4 in.). No organisms were found either by microscopic or cultural tests.

Small, reddish brown spots 3 to 4 mm (0.12 to 0.16 in.) in diameter on leafstalks were common in the northern part of the delta region of Egypt near the Mediterranean. No organisms could be found in these. Since they were thought by an entomologist to be due probably to some sucking insect like a jassid, they might be known as stigmanose. On various minor spots on date palm midribs in North Africa, various fungi were found, including species of *Anthostomella, Phomopsis, Phoma, Gloeosporium, Didymosporium,* and *Mycosphaerella,* in addition to those previously mentioned.

LIST OF FUNGI FOUND BY THE AUTHORS ON DATE PALMS IN CALIFORNIA AND ARIZONA

Acrostalagmus sp., isolated from roots and dying leaf buds.

Alternaria citri Pierce, isolated from brown spots on fruits. (See section on "Brown Spot.")

Anthostomella contaminans (Dur. and Mont.) Sacc., isolated from leaf bases.

Anthostomella sp., on leaf.

Aspergillus flavus Link, isolated from fruits and leaves.

Aspergillus niger v. Tiegh., isolated from fruits and leaves. (See "Calyx-End Rot.")

Aspergillus terreus Thom, isolated from leaves.

Catenularia fuliginea Saito, isolated from moldy fruit. (See "Minor Fruit Rots.")

Cephalosporium sp., isolated from leaf.

Chaetomium sp., isolated from dying fruit stalk.

Citromyces ramosus Bainier and Sartory, isolated from fruit. (See "Minor Fruit Rots.")

Cladosporium sp., isolated from side spot on fruit.

Diplodia phoenicum (Sacc.) Fawcett and Klotz, isolated from leaf bases and inflorescences. (See "Diplodia Disease.")

Epicoccum sp., isolated from leaf.

Flammula earlei Murr., growing on trunk.

Fusarium spp., isolated from roots, leaves, and inflorescences. (See "Inflorescence Decay.")

Graphiola phoenicis (Mong.) Poit., found growing on leaves. (See "Graphiola Leaf Spot.")

Gymnoascus setosus Eidam., isolated from leaves.

Helminthosporium molle Berk., and Curt., isolated from brown spots on fruits. (See "Brown Spot.")

Penicillium roseum Link, isolated from leaf bases and buds. (See "Minor Fruit Rots.")

Phaeochora sp., isolated from leaf base.

Phomopsis phoenicicola Trav. and Spessa., isolated from leaf bases and from spots on leaf pinnae.

Poria sp., found growing on trunks.

Rhizopus sp., found growing on fruits.

Rhizophoma (?) sp., isolated from leaf bases.

Stemphylium sp., isolated from spots on leaves.

Thielaviopsis paradoxa (De Seynes) v. Höhn., isolated from leaves, buds, and inflorescences. (See "Black Scorch" and "Inflorescence Decay.")

Trichoderma lignorum (Tode) Harz, isolated from roots.

Verticillium sp., isolated from leaf bases.

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